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Abattoir Waste Contribution To Municipal Waste Generation

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ABSTRACT

Increased population means increased demand for meat. Thus, more slaughter waste is expected to be generated. Knowing an estimated quantity of waste generation can help in planning and influence the type of management systems needed for now and for the future. There are no sufficient measures or facilities to treat wastewater for environmental safety. An investigative survey and quantitative approach were used to evaluate the combined waste generation for Kperisi and Kambali slaughter houses (abattoirs) and management of same in Wa Municipality of Upper West Region over a period of six months (172 days), where 5,848, 35% of all slaughtered livestock for study period were randomly selected and measured as an average representative for the respective types. Schaeffer's formular was used to determine the live weight of 2,064 cattle, 2580 goats and 1204 sheep out of 16,856. Average live weights were 543.30 kg for cattle, 45.31 kg for goats and 56.42 kg for sheep generating 0.52 tons of blood, 0.38 tons of intestinal content, 0.29 tons of tissues and 0.58 tons of bone as daily abattoir waste, translating into 179.57 tons of blood, 130.38 tons of intestinal content, 100.17 tons of waste tissues and 196.77 tons of bone annually, based on standard waste per slaughter for these livestock. Annual waste of 606.88 metric tons and 1,300.035m^3 of waste water are generated every year based on the study. The enormous volume of waste makes the issue of meat safety risks associated with its disposal an immediate, ongoing and serious one.

KEYWORDS: Abattoir waste; Schaeffer's formular; Body measurement; Live Weight; Waste generation

INTRODUCTION

Ever since humans tied down their health and well-being to the quality of their environment, sanitation which ought to have been one of the determinants of the quality of life has been neglected, (Burmamu et., al., 2014). A decade ago, 2.9 billion urban residents generated about 0.64 kg of municipal solid waste (MSW) per person per day, with an estimated future amount of 0.68 billion tonnes per year due to urban lifestyle growing faster than the rate of urbanization, (Hoornweg and Bhada-Tata, 2015). As countries urbanize, their economic wealth increase with standards of living and disposable incomes increasing, consumption of goods and services increases, which results in a corresponding increase in the amount of waste generated. The problem of waste disposal in the world continues to grow with industrialization and population growth (Bassis, 2009).

Developed countries have well developed management facilities and logistic systems are developed to ensure smooth flow of material from one point to another where as in developing countries there is lack of or inadequate waste management facilities and systematized management to ensure a smooth flow of the waste from one point to another (Tettenborn et al., 2007). Persons living in industrialized nations such as the United Kingdom, France and the United States of America generate as much as 695 kg, more than 1,500 lb. of municipal solid waste in the form of pollution, (Hoornweg and Bhada-Tata, 2015). Waste generation in Sub-Saharan Africa is approximately 62 million tonnes per year with per capita waste generation generally low, but spans a wide range, from 0.09 to 3.0 kg per person per day, with an average of 0.65 kg/capita/day, (World Bank, 2015). This same report indicates that by 2025 this will likely increase to 4.3 billion urban residents generating about 1.42 kg/capita/day of municipal solid waste (2.2 billion tonnes per year) as indicated in Figure 1.0. As countries urbanize, their economic wealth increase. As standards of living and disposable incomes increase, consumption of goods and services increases, which results in a corresponding increase in the amount of waste generated. Slaughterhouse waste and by extension solid waste is inextricably linked to urbanization and economic development.

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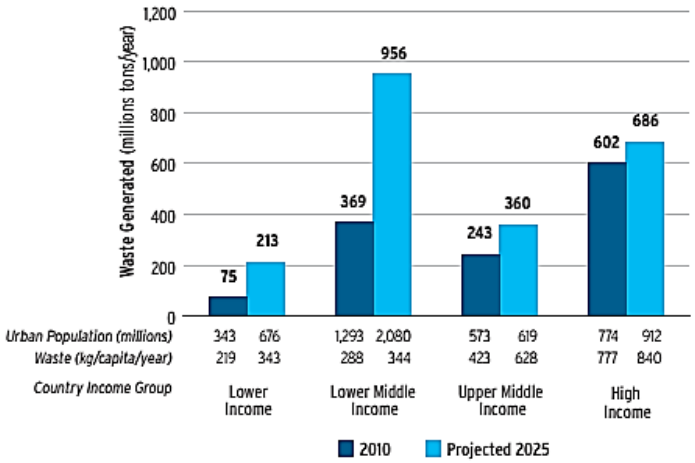

Figure 1.0: World Bank report (2015) on Waste Generation Levels
Source: What a Waste, Urban Waste Generation by Income Level and Year

Abattoir operations produce a characteristic highly organic waste with relatively high levels of suspended solid, liquid and fat, (Adeyemo & Adeyemi, 2007). Approximately 50–54% of each cow, 52% of each sheep or goat, 60–62% of each pig, 68–72% of each chicken and 78% of each turkey end up as meat consumed by human beings with the remainder becoming waste after processing (Alonge, 2005; Scotland Regulations 2003). Slaughter house waste management is a major development challenge in Wa. Food contamination at every stage of the food production chain is unacceptable since it threatens the health of consumers of such foods. Demand for protein food from both plants and animal sources have increased to address malnutrition issues (Obiri-Danso et al., 2008). In the Wa abattoirs, the open heaps are not removed in time and this cause percolation into surface waters. Coupled with weak institutional capacity, and lack of resources (both human and capital), the authorities face difficulties in ensuring that waste generated at the abattoir is collected for disposal. This provides complex multidimensional negative effects for human health risk and environmental contamination. This deserves not only the attention of the Municipal Assembly and the waste management institutions but also corporate organizations and individuals to find a lasting solution to the problem. The former Upper West Regional Minister Dr. Ephraim Avea Nsoh is reported to have lost his appetite on his visit to the abattoir due to the appalling nature of the slaughter house, (GNA, 2014).

The amount of slaughter waste contribution to municipal waste will increase as population increases and it is therefore important to estimate how much waste slaughterhouses contribute to enable proper and appropriate remedy. measures to be put in place to deal with it. Some waste disposal in pits now called landfill has been developed to include different types of waste that cannot simply be dumped into a hole due to their effects on the environment (Bogner et al, 2007). These problems, however, also have provided opportunities for cities to find solutions that involve the community and the private sector, including innovative technologies, disposal methods, and behavior Changes, (Adeyemo & Adeyemi, 2007). The objective of the study is to assess waste management in the Wa municipality abattoirs and obtain the slaughter waste contribution to municipal waste. An attempt is also made at estimating the volume of meat produced at the abattoir and the corresponding effluent generated (solid and liquid), (Fearon et., al., 2014). This may be achieved by the following specific objectives;

- To evaluate the various waste management practices at the abattoir to establish severity or otherwise
- Evaluate percentage of waste generated per slaughter
- Estimating the volume of meat produced at the abattoir and the corresponding effluent generated

Present Scenario and Existing disposal options available at Abattoirs

The following are methods employed to dispose of waste at the abattoirs; Dumpsite, Nearby drains, Roadside and Open Space Dumping. Typical examples are shown in Figures 2.1 and 2.2.

Figure 2.1: Ash by roadside at Kperisi Abattoir.

Figure 2.2: Bones disposed of at Kperisi Abattoir

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Slaughtering **-** of cattle is mostly, by Halal method preferred by Muslims, done in a humane way by stunning of animals. There is no stunning of sheep and goats before slaughtering.

Composting**:** Used as fertilizer and it is usually cheaper than rendering or incineration. However, it requires significant land, earth moving equipment and material high in carbon. The compost must also be disposed of and may include portions of bones.

Figure 3.0: Kperisi Lairage. Cattle are kept between 8 – 13 hours before slaughter. Notice size of cattle in right picture.

Incineration**:** Waste incineration is expensive and poses challenges of air pollution and ash disposal. Incineration requires waste placed outside for collection to be containerized to stay dry, and much of the waste stream is not combustible. Incineration may be used to dispose of all abattoir waste and carcasses. Thompson (2005), concludes that "if enhanced incinerators can be located in suitable, environmentally resilient sites, that technology may provide a suitable, affordable, alternative for the disposal of slaughterhouse waste".

Land spreading**:** Solid waste transported off-site is normally taken to a landfill site. The waste is placed in a large excavation (pit or trench) in the ground, which is back-filled with excavated soil each day waste is tipped. Ideally, about 0.5m of soil should cover the deposited refuse at the end of each day to prevent animals from digging up the waste and flies from breeding landfills require land availability, and siting is often opposed by potential neighboring residents. Animal paunch is most left in the open as shown in Figures 4.1 and 4.2, some using decomposed paunch as manure.

Figure 4.1: Open disposal of paunch at Kperisi Abattoir.

Figure 4.2: Nearby farmers collect these as manure

Bleeding **-** in both places of slaughtering, blood collection is not done immediately after slaughtering and most of the blood goes down into municipal drains causing pollution. Blood of the animals, which can be collected for making use in pharmaceutical industry, is thus by and large lost.

Dressing **-** due to lack of means and tools, dehiding of the carcasses is done on the floor itself, which causes contamination of the meat. The hides and skins are spread on the killing floor. Similarly, legs, bones, hooves etc. are not removed immediately from the slaughtering area.

Figure 5.0: Dressing of Carcass at Kambali Abattoir.

Figure 6.0: Dressing of Carcass at Kperisi Abattoir.

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Evisceration - this particular process generates maximum amount of waste. Uncontrolled slaughtering of animals by other butchers results in throwing visceral material at the community bins and wash the small intestines at their individual shops itself and thus create pollution problem.

Figure 7.0: Boning of Carcass at Kambali Abattoir. Notice the scale on table for selling.

Figure 8.0: In background is more dressing ongoing

MATERIALS AND METHODS

Study Area

Wa is a growing city just like other Metropolitan areas such as Kumasi and Accra and as such is facing the problem of effectively managing its slaughter house waste. As abattoirs serving 107,214 people, (GSS, 2010), it is important animals are slaughtered in a clean environment with proper waste management system. It has on-site shops where slaughtered meat is sold. The two slaughterhouses in Wa municipality, Kambali abattoir and Kperisi abattoir, are located at N 10° 03' 36.2"; W 002° 30' 54" and N 10° 05' 21.5"; W 002° 28' 51.6" respectively. All cattle are slaughtered at Kperisi while goats and sheep are slaughtered at Kambali. These are distinct conventions operating amongst the butchers. Figure 9.1a and Figure 9.2a show the infrastructural difference between the two "slaughter houses" while Figure 9.1b and Figure 9.2b show their respective geographical location with a little background view.

Figure 9.1a: Kperisi Abattoir. Sheltered

Figure 9.2a: Kambali Abattoir Un-sheltered.

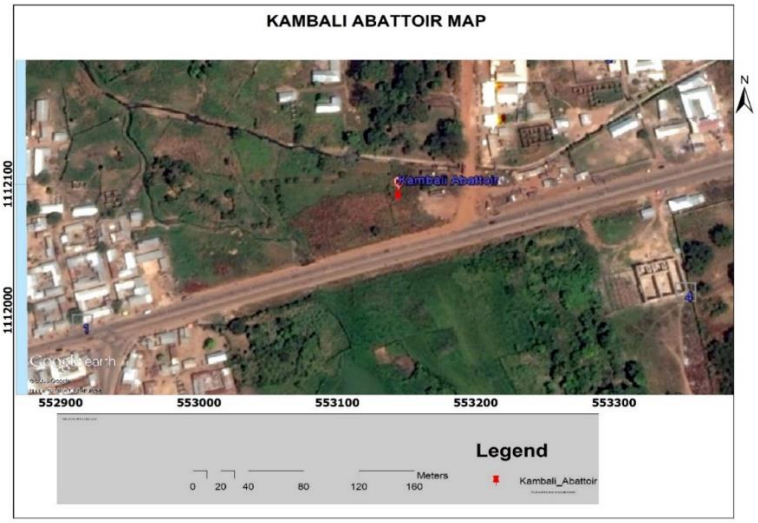

Figure 9.1b: Location of Kambali Abattoir. Notice the drain passing behind it. Source: Google earth, gridded in ArcMap.

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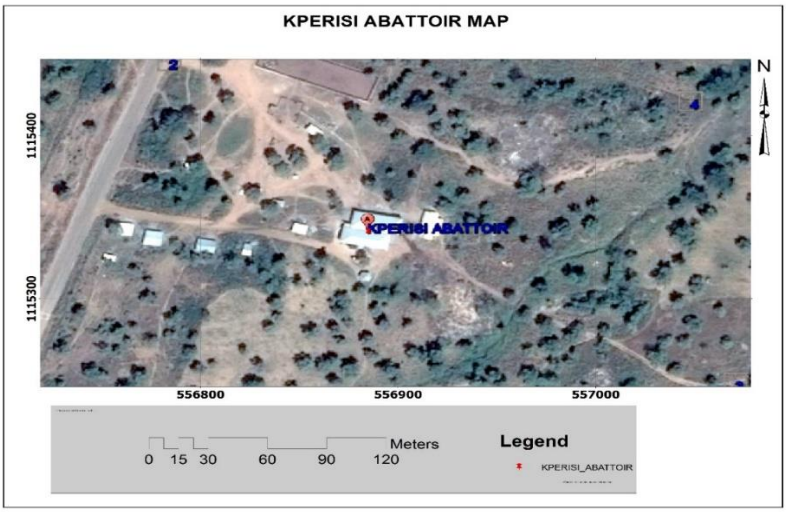

Figure 9.2b: Location of Kperisi Abattoir. Notice the farmlands behind it.
Source: Google earth, gridded in ArcMap.

Work Plan

The study was conducted over a six months' period strategically chosen to reflect the various seasons of the year and the buying pattern of inhabitants within Wa municipal. The two main abattoirs are the *Kambali Abattoir* for **Goats** and **Sheep** only and the *Kperisi Abattoir* for **Cattle** only. Table 1 shows the results of the counting over the study period. There was an average of 15.6% for cattle, 11.1% for goat and 20% deviation from what was obtained from the respondents. The deviations in count depict the ineffectiveness of records keeping at both abattoirs, by both the abattoir managements and the Wa Municipal Inspection Directorate.

Obtaining the daily slaughter count for body measurement

Table 1. Count and percentage representation of sample population

LIVESTOCK	DAILY COUNT	1/3 OF COUNT	PERCENTAGE PER DAY	PERCENTAGE PER MONTH	PERCENTAGE OVER PERIOD
CATTLE	38	12	31.57	13.07	13.22
GOAT	40	15	37.50	15.52	15.70
SHEEP	20	7	35.00	14.48	14.65

Source: Field Survey (Physical measurement with two helpers at each abattoir)

Six months' study period represents fifty percent (50%) of the entire year and can suffice as a true representation of events of daily slaughter at the two abattoirs. Three festive months as well as three non-festive (seasonal) months were chosen. The festive months were chosen because it is assumed demand for meat is high during these times, therefore it is assumed slaughter house waste is expected to be high. The second set of three months were chosen to be a representative of the normal (ordinary) or various seasons of the year which illustrates abattoir waste generation behavior throughout the year. Table 2 summarizes the periods used.

Table 2. Six-month study period and seasons of study

S/N	MONTHS/ SEASONS	ACTUAL PERIOD	DAYS USED	PERIOD DESCRIPTION/ REASONS FOR CHOICE
1	Christmas Season	13 Dec '15 - 10 Jan '16	29	Demand is high due to need to share
2	Easter Season	March 2016	28	Demand is high due to need to share
3	Ramadan Season	June 2016	28	Lot of soup taken after fast each day
4	Dry/ Harmattan	February 2016	29	Price is cheap, influx due to non-farming
5	Wet/ Rainy Season	May 2016	29	Price is high, scarce due to farming
6	Normal Month (Outside of above)	April 2016	29	Buying behavior pattern, normal times
		TOTAL	**172**	

Study period December 2015 – June 2016 (172 days, an average of 28.7 days per month)

A third of each day's count was chosen and measured for each species as shown in Table 1. Live weight of animals intended for slaughter is the weight taken immediately before slaughter. At the abattoirs, no weighing is done by the butchers and operators throughout the process except at the point of sales. However, objectives of the study dictate that some weighing be done and since there was no scale at either of the abattoirs it was important to use an alternative, both for information confirmation and collection of new data. The following methods are available for obtaining the live weight of livestock.

- **Direct method**: Animal is weighed directly on weighing machines or platform scales.
- **Alternate method / indirect method**: In this method, weight of an animal is indirectly calculated from body measurements, also known as Schaeffer's formula and it is widely accepted for estimating body weight of an adult cattle and other ruminants.

Schaeffer's formula: $W = \frac{L\ X\ G^2}{300} = \frac{Lenth\ X\ Girth^2}{300}$; ……. **equation 1** where W is the live weight of animal in pounds, L is the Length of animal measured from the shoulder to the pin bone, in inches and G is the Girth or the entire circumference of the body measured behind the point of elbowing, in inches;
Where **1lb. = 0.45359kg**

Obtaining the live weight, daily slaughtered weight and carcass weight

One third of a daily quota for each group of livestock was randomly picked every other day on three days in a week - at the ***beginning***, at ***mid-week*** and at ***weekend***. The averages of these were used as the average body measurement of the various categories respectively. Statistically it is a fair representation and can be used as the average weight of each category of slaughtered animal. An average of twenty-nine days each in the respective periods of Table 3 (slaughtered livestock) gives a four-week routine measurement cycle for each type of livestock. Thus, 2,064 cattle were measured out of 6,536; 2,580 goats were measured out of 6,880 and 1,204 sheep were measured out of 3,440.

Table 3. Total slaughtered livestock at abattoirs for six months' period

Livestock	Christmas	Easter	Ramadan	Harmattan	Rainy	Normal	Total
Sheep	580	560	560	580	580	580	**3440**
Goat	1160	1120	1120	1160	1160	1160	**6880**
Cattle	1102	1064	1064	1102	1102	1102	**6536**
TOTAL	**2842**	**2744**	**2744**	**2842**	**2842**	**2842**	**16,856**

Source: Field Survey (Physical count with two helpers at each abattoir)

Each month gives twelve weighing days where the average of these measurements give the daily average respectively and an average of this gives a monthly figure. The average of six months gives the average figures of body measurement for cattle. The same approach is replicated for goat and sheep proportionally according to the daily number of slaughter. Next was to use these average lengths and girths in equation 1 to estimate the average live-weight for each category of livestock. These are then multiplied by the number of slaughter in a day for each category to obtain the total average weight of slaughtered livestock from the two the abattoirs. For carcass weight, a simpler perspective of carcass weight was employed, with livestock and slaughter wastes being defined as any product that is not the meat tissue. Thus, bones, hides, hooves, horns, and the multitude of offal products are also considered as wastes, even though they are often consumed, re-used, or recycled in various ways, (World Bank study, 2009). Similar works suggests averages and workable figures for finding the carcass weight as shown in Table 4.

Table 4. Typical carcass % and Dressing Percentage of species

Livestock	Average live weight (kg)	Carcass (%) live weight	Carcass (%) live weight	Average dressing percentage (%)
Cattle	250	50	55	58 – 63
Sheep	25	60	47	50 – 53
Goat	22	55	47	45 - 50

Source: World Bank Report, 2009 – additions Curled from Gregg, 2010

Dressing percentage is the percentage of an animal's live weight that is its carcass weight. Used to estimate a live animal's carcass weight from its live-weight: carcass weight / final live weight x 100.

$$\boldsymbol{Criteria}: \boldsymbol{Meat\ Production}(\boldsymbol{Mt}) = (\boldsymbol{Off\ take\ rate}\ \%) \times \boldsymbol{Estimated\ Population} \times \boldsymbol{Carcass}\frac{\boldsymbol{weight(kg)}}{\boldsymbol{1000}}$$

equation ……2

Offtake rate is the percentage of animals slaughtered in a given year. For purposes of this study however, off take rate × estimated population stated in the formula was substituted with the observed number of livestock slaughtered daily at the abattoir, (Fearon et. al., 2014).

Estimating the total Slaughter Waste

Using the waste per slaughter and the number of livestock slaughtered daily an estimation of amount of solid carcass waste generation is obtained, assuming that the waste generated is the unsold part of the slaughtered animal. The simplest way of estimating or measuring the amount of water used or 'wasted' at the abattoir would be having a system of measurement, however this was non-existent. Using the Ghana Water Company Limited (GWCL) consumer bill issued to the management of the abattoir, the number of units of water was estimated. Using equation 3 the volume of consumption is estimated; as

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$$1\ unit\ of\ water = 1\ cubic\ meter = 1m^3 = 1000\ litres \quad \text{..... equation 3}$$

To obtain the volume per slaughter for each livestock, it's the ratio of the total livestock of specie to total unit for a particular abattoir. Thus, Kambali use 24.67 units of water for sheep and 49.33 units of water for goats. Water used by humans can easily be neglected as it is insignificant compared to the volume used for the butchering activities. A total of 1,300,037.92 litres a year gives 3779.22 litres of waste water in a day from both abattoirs.

RESULTS AND DISCUSSION

Questionnaires suggested that about one hundred and fifteen **(115)** livestock are slaughtered daily between the two abattoirs in the Municipality. However, the field survey gave a total deviation of **14.7%** pegging the total daily number of slaughtered livestock at ninety-eight **(98)**. This difference may be due to non-availability of records at either abattoir. It is important to note that **61.22%** of daily slaughtered livestock is contributed by Kambali Abattoir, with Kperisi Abattoir contributing **38.78%**, from Table 4.1. The level of percentage deviations depicts or confirms the ineffectiveness of records keeping at both abattoirs, by both the abattoir managements and the Wa Municipal Inspection Directorate. Six months' study period represents fifty percent (50%) of the entire year and can suffice as a true representation of daily slaughter events at the two abattoirs. An average of 29 days for all the chosen periods gave a fair base for counting and comparison. Figure 10 is a bar representation of the total slaughter per each period chosen over the entire study period.

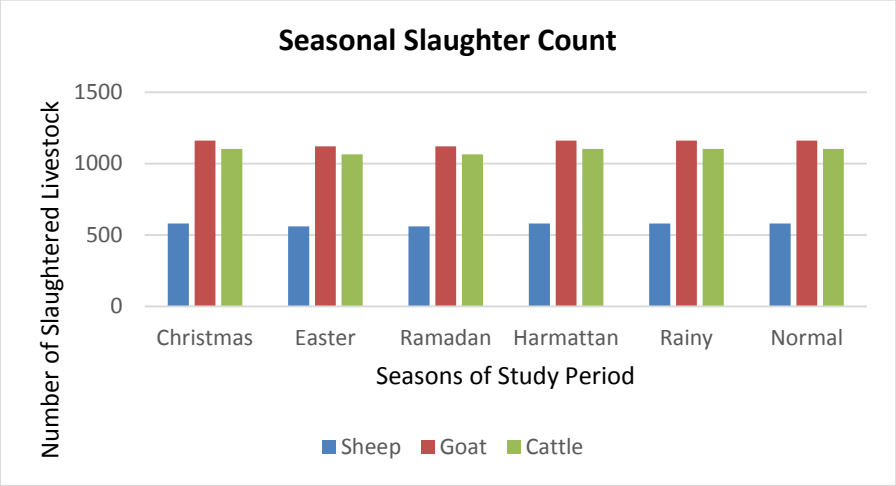

Figure 10: Livestock slaughtered per season. Source: Field survey, 2016

Figure 11.1 and 11.2 give the percentages of slaughtered livestock for a day and six-month period. Notice that statistically it does not make any difference whether the daily count is used or the entire six-month count is used, because the latter is only a multiple of the former. Thus 41% of the slaughtered livestock come from Goats, 39% from Cattle and 20% from Sheep. These percentages could be interpreted as the percentage of choice meat by the populace to the extent of these three livestock. Figure 11.3 shows the percentage representative of count for measurement.

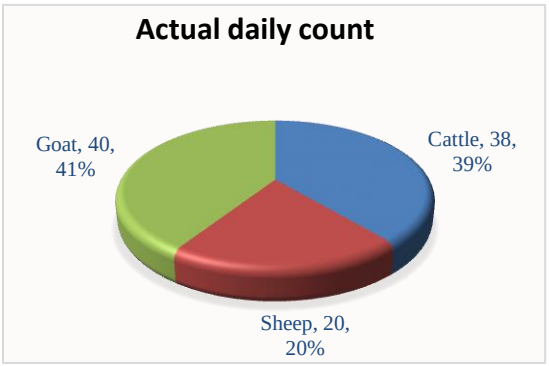

Figure 11.1: Composition of daily livestock slaughtered

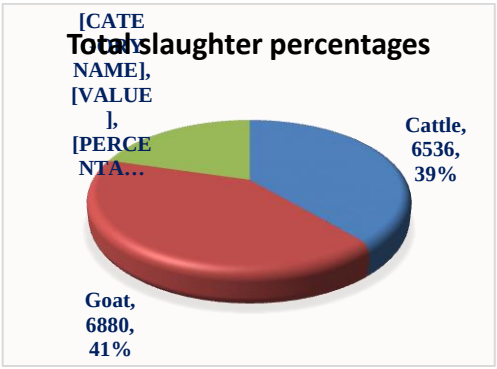

Figure 11.2: Total Percentage of livestock slaughtered

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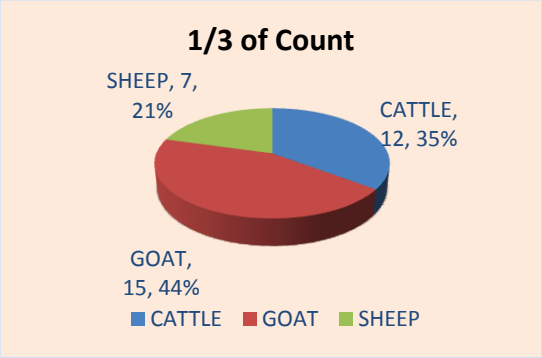

Figure 11.3: Measured Livestock Percentages

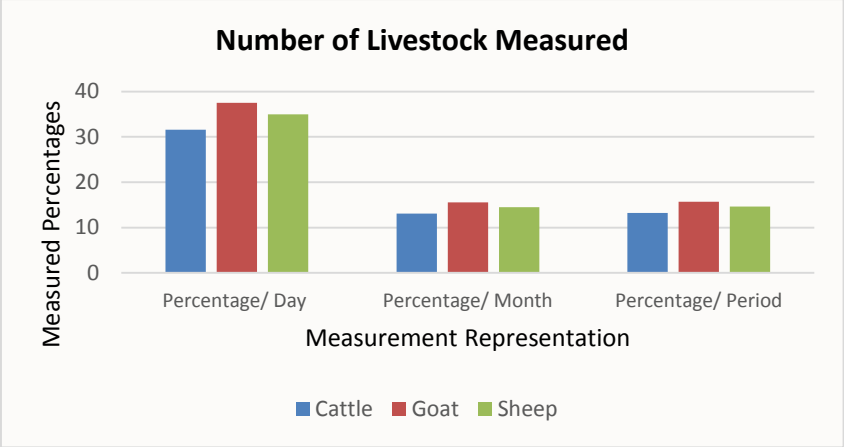

Figure 11.4: Daily, Monthly & Period measured representation

Statistically, 25% of a sample size for any analysis is quite good and acceptable as a depictive representative characteristic of the whole population. Using the elevation factor which is the quotient between the size of the population and the size of the sample, it represents the number of elements existing in the population for each element of the sample. Thus, a 33% representation of individual percentages are shown in Figure 11.3 and Figure 11.4 where each measured livestock represents three of its category, with a narrow spread.

Table 5. Average Live weight per Slaughter; total slaughter weight in six months

Livestock	Average Length (in)	Average Girth (in)	Average weight (lbs)	Average weight (kg)	Daily Total Wt. (metric tons)	Period Total Weight (metric tons)
Cattle	66.17	73.69	1197.66	**543.30**	20.6454	3551.0088
Goat	30.55	31.32	99.89	**45.31**	1.81240	311.7328
Sheep	31.96	34.17	124.38	**56.42**	1.12840	194.0848

***NB: (Live weight)/1000 X number of animals over study period = weight in metric tons**

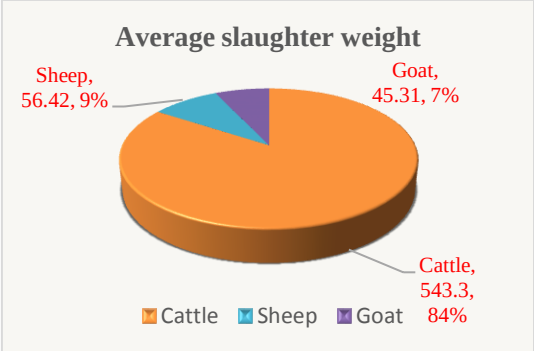

Figure 12.1: Composition of daily livestock slaughtered

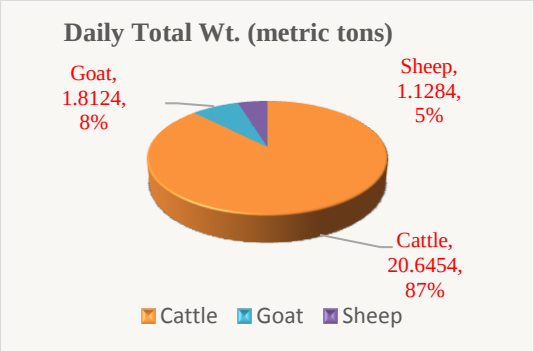

Figure 12.2: Composition of daily livestock slaughtered

Most authors apply body measurement in determining the weight of specific specie of livestock category. It may be applied to finding the weight of Gwembe and Saanen goats or Bonga and Horro sheep, for different age range. However, those details were not considered per the objective of the research. It will therefore be irrelevant if details are given on specie. Table 5 shows the

average body measurement figures obtained using Schaeffer's formular. Aniebo et al, (2013), gives the same weight for both goat and sheep. It must be noted that this will depend greatly on the type of specie used in the exercise. It is important to note also that Upper West Region share border with Cote D'Ivoire and Burkina Faso. It will therefore not be surprising if species from these areas find themselves on the Wa Municipal market, the capital market of the region. This would have contributed to the difference in live weight between goat and sheep in this exercise based on the sample randomly selected. It could be loosely argued that, farmers are adhering to advice from vertenaries hence are taking good care of livestock increasing their body weight over the years, from when Aniebo and his friends did the study in 2011. Hence Table 5 and Figures 12.1 and 12.2 are representative enough.

Relying on the world Bank's Report (2009) estimation coupled with estimation by Gregg (2010), an estimated average of carcass weight percentage of live weight was applied to the average live weight to obtain the dressing percentage. The solid slaughter waste weight is therefore the difference between the live weight and the carcass weight. All three categories show less than 50% waste weight. Table 5 gives a daily total slaughter weight when all average weights are multiplied the number of respective slaughter and summed up. This yields a total of 23,586.2 kg (23.6 metric tons) of slaughter weight based on the data for the study period. The slaughter waste weight is the sum of the waste per slaughter multiplied by the respective slaughter count. This gives a figure of 10,393.72 kg (10.39 metric tons) each day. It must be noted that, an assumption is made, in that, waste per slaughter as calculated indicates that everything minus carcass is waste, including all intestines, all bones, etc.

This may not be exactly true as some intestines are sold as well as some bones together with edible meat. It is interesting to note that all category of livestock has over 50% of its live weight as carcass weight. This therefore means for the three types of livestock that come to the abattoirs, each has over 50% of live weight as good meat or sellable meat. Based on the carcass weight, Table 6 gives a total carcass weight per slaughter as 360.25 kg, with a total meat production of 13,192.48 kg per day and 4,544.24 metric tons annually as shown in Table 7.

Table 6. Carcass weight per Slaughter; slaughter weight in six months

Livestock	Average weight (kg)	Average range carcass %	Actual carcass %	Carcass Weight (kg)	Waste per slaughter (kg)	Total Waste in metric tons
Cattle	**543.30**	50 – 63	56.5	**306.96**	**236.34**	1544.72
Goat	**45.31**	47 - 55	51.0	**23.11**	**22.20**	152.74
Sheep	**56.42**	47 - 60	53.5	**30.18**	**26.24**	90.27
TOTAL				**360.25**	**284.78**	**1,787.73**

NB: Total waste calculation is based on the six-month study period. Carcass % is the dressing %

This figure assumes that no bones, intestines, liver, lungs and paunch are sold as meat. Implying that the actual (edible) meat production could be more even based on these three livestock only.

Table 7. Meat Production at the two Abattoirs

Livestock	Average weight (kg)	Carcass Weight (kg)	Daily slaughter count	Meat Production (kg)	Daily Meat Production (metric tons)	Yearly Meat Production (metric tons)
Cattle	**543.30**	**306.96**	38	11664.48	11.664	4,012.416
Goat	**45.31**	**23.11**	40	924.40	0.942	324.048
Sheep	**56.42**	**30.18**	20	603.60	0.604	207.776
TOTAL		**360.25**	**98**	**13,192.48**	**13.21**	**4,544.24**

Dressing percentage is affected by what parts of the goat are being included in the carcass weight

Estimating the waste generation from abattoirs

Abattoir waste is in two parts. Solid part and the liquid part. With a slaughter waste of 284.78 kg per each slaughter (three livestock put together), it translates into 10.39 metric tons of slaughter solid waste per day and a whopping 3, 575.44 metric tons annually. These are adequately depicted in Table 4.6.

Table 8. Waste generated per animal per slaughter

Livestock	Average weight (kg)	Carcass Weight (kg)	Waste per slaughter (kg)	Waste per day (kg)	Waste per year (kg)	Total Waste in metric tons
Cattle	**543.30**	**306.96**	236.34	8,980.92	3,089,436.48	3,089.44
Goat	**45.31**	**23.11**	22.20	888.0	305,472.0	305.47
Sheep	**56.42**	**30.18**	26.24	524.8	180,531.2	180.53
	TOTAL		**284.78**	**10,393.72**	**3,575,439.68**	**3,575.44**

Source: Data from Field Survey 2016

In Table 8 the figure of 3,575.44 metric tons per year does not consider edible parts such as intestines. Table 9 takes care of that where the waste categories have been specified by Aniebo et. al., (2011), and confirmed by Fearon et. al., (2014). Based on their study, the various waste categories have a standard (used over time by several authors and acceptable) weight for each type of slaughter solid waste for these three livestock. That used produced 1,764.2 kg of slaughter solid waste daily with an annual yield of 606.88 metric tons. Each slaughter though contributes 38.8 kg for cattle, 4.83 kg for goat and also 4.83 kg for sheep. Based on these two approaches, Table 9 produced about 17% of annual waste of what Table 8 produced.

Table 9. Waste generation at abattoirs

Waste Category	Cattle		Goat		Sheep		Total/day	Total/ yr.
	38/ day		40/ day		20/ day		98/ day	344 days
Blood/ head (kg)	12.6	***478.8***	0.72	***28.8***	0.72	***14.4***	***522.00***	**179,568.00**
Intestinal content/ head (kg)	8.0	***304.0***	1.25	***50.0***	1.25	***25.0***	***379.00***	**130,376.00**
Waste tissue/ head (kg)	6.4	***243.2***	0.8	***32.0***	0.8	***16.0***	***291.20***	**100,172.80**
Bone/ head (kg)	11.8	***448.4***	2.06	***82.4***	2.06	***41.2***	***572.00***	**196,768.00**
TOTAL	**38.8**	***1474.4***	**4.83**	***193.2***	**4.83**	***96.6***	***1,764.20***	**606,884.80**

Source: Adapted from Aniebo et. al., 2011, Fearon et. al. 2014; Data from Field Survey 2016

The liquid waste is mainly water used at the abattoir floor for washing blood and then also that used at the lairage. It may also include water used by humans, thus it can easily be equated to the water usage at these abattoirs. Table 10 depicts the usage in units (scale of measurement for water consumption by Ghana Water Company Limited) for the six seasons under the study period. Over the period 74 and 576 units of water were used at the Kambali and Kperisi abattoirs respectively. This translates into 88.13 liters for each slaughtered cattle and 7.17 liters each for every slaughtered sheep and goat, and an annual waste water of 1,300.035m^3.

Table 10. Volume of Waste water generation at abattoir

Season/ Period	Kambali	Kperisi	Total Volume	Waste Volume/ slaughter (litres)		Volume per year (litre)
Christmas Season	10 units	100 units	110 units	***Cattle***	88.130	**1,152,035.36**
Easter Season	15 units	105 units	120 units	***Goat***	7.170	**98,659.20**
Ramadan Season	12 units	90 units	102 units	***Sheep***	7.172	**49,343.36**
Dry/ Harmattan	12 units	90 units	102 units	Total Cattle =	6536	Cattle = 1,152.035m^3
Wet/ Rainy Season	10 units	95 units	105 units	Total Sheep =	3440	Goats = 98.66m^3
Normal Month	15 units	96 units	111 units	Total Goats =	6880	Sheep = 49.34m^3
	74	576	650 units	Slaughtered Livestock count over the study period		**1,300,037.92**

Source: Ghana Water Company Limited; Field survey, 2016

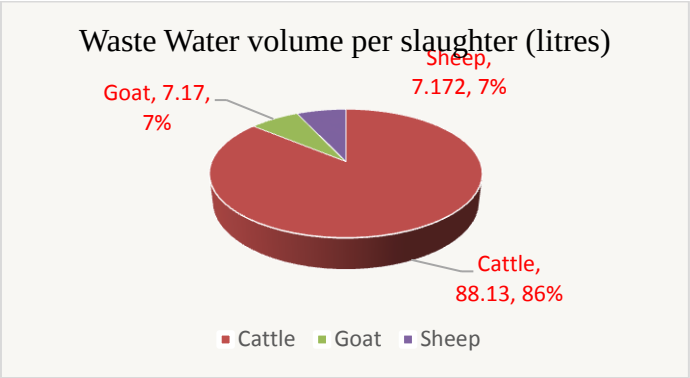

Figure 13.1: Water consumption per slaughter

Figure 4.6 tells the percentage water consumptions for each slaughter of cattle, goat and sheep whereas Figure 4.7 shows the water consumptions for each season during the study period for the abattoirs.

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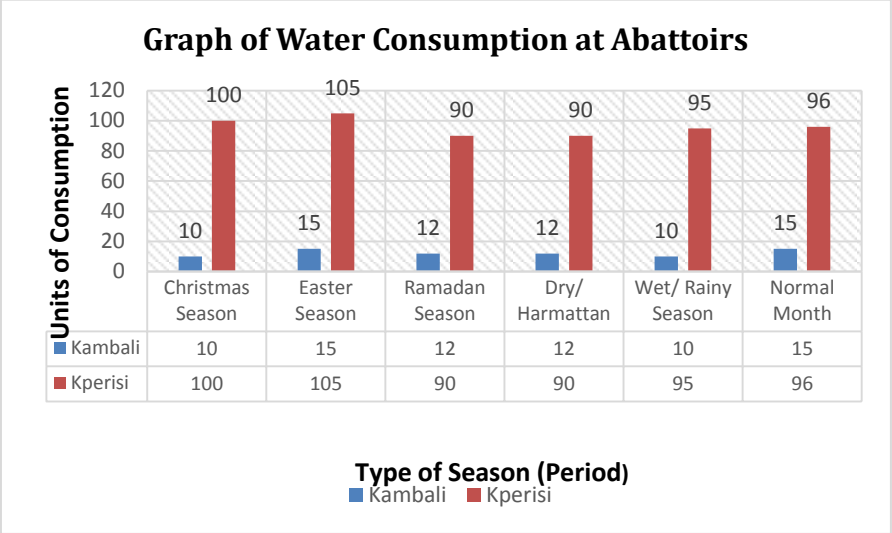

Figure 13.2: Graph of Monthly Water Consumption at Abattoirs

The average lengths and girths were 66.17 and 73.69, 30.55 and 31.32, and 31.96 and 34.17 for cattle, goats and sheep respectively, all in inches.

CONCLUSION

Abattoirs aim at optimizing the recovery of edible portions from the meat processing cycle for human consumption. Significant quantities of secondary waste materials not suitable for further consumption are however generated. Since water is often used to wash excessive waste solids to drain, waste solids should be carefully managed to promote water conservation.

The waste-handling practices, almost without exception, did not fully comply with the following requirements;

- Food and Drugs Authority by Public Health Act, 2012, Act 851, Part Seven, Section 148, Subsection (2g).
- FDA by Public Health Act, 2012, Act 851, Part Seven, Section 108,
- Food and Drugs Authority (FDA) and the Veterinary Services Directorate (VSD) by Public Health Act, 2012 (Act 851), Part Seven, Section 108,

These codes of practice apply to the regulation of slaughter houses and slabs in a manner that ensures the safety and quality of carcass are obtained from such places. They also apply to all slaughter houses and butchery in Ghana and is intended to provide such facilities with the requirements of the FDA provided by the Public Health Act, 2012 (Act 851). The abattoir waste materials are entirely organic that can either be composted or recycled and used for various activities, yet they are left to degrade, producing bad stench. Degrading heaps of gut contents at the site serve as breeding grounds and sanctuary for pests that become a nuisance for abattoir workers, visitors as well as residents around the facility. Blood and liquid intestinal fluids are washed into a drain that empties right at the premises of the abattoir as depicted by Figure 8. These are washed by rains into nearby streams and dugouts that serve as sources of water for other communities. Solid intestinal contents are collected in wheelbarrows and deposited at designated points depicted in Figure 4.1 and Figure 4.2. Bone waste is currently left by the road side as shown in Figure 2.1 and 2.2.

Table 7 shows the average (daily and yearly) estimates (Mt) of the quantity of meat produced. The results show that annually, 4,012 tons of beef - representing over 18.9% increase of the 2012 national output for Ghana (MOFA, 2014) came from the two abattoirs. In addition, an increase of about 1.1% and 1.5% of the 2012 national output of mutton and chevon, respectively was produced. These results show that activities at the abattoir contribute significantly to the total national meat output, providing employment for a number of people in the metropolis. There are however, serious concerns regarding the methods adopted in processing and handling of the meat as well as management of waste materials. In terms of the slaughtered numbers, Wa contributes 5.93% of cattle, 7.59% of sheep and 9.76% of the national slaughter numbers of 2012 figures. On the average, 98 livestock were slaughtered daily at the abattoirs. In summary, the 38 cattle, 20 sheep and 40 goats slaughtered daily lead to the generation of about; 0.52 metric ton of blood, 0.38 metric ton of gut contents, 0.29 metric ton of waste tissues and 0.58 metric ton of bone. These translate into annual total of about 179.57 metric tons of blood, 130.38 metric tons of intestinal contents, 100.17 metric tons of waste tissues and a total of 196.77 metric tons of bone that would otherwise have been part of the annual waste generation was excluded because they are often sold together with the meat. In other words, between when the abattoir was commissioned 2013 and by the end of 2016, an estimated 718.28 metric tons of blood, 521.52 metric tons of intestinal contents and 400.68 metric tons of waste tissue have been discharged into the environment. The total slaughter solid waste in a year based on simple carcass weight from live weight is **3575.44** metric tons. However, based on Aniebo's estimation, **606.88** metric tons of

solid slaughter waste is generated by the two slaughter houses annually with a combined waste water volume of **1300.035** m^3. This is the amount of waste contribution by the slaughter houses to the municipal total waste.

Table 11. Comparison of weights of livestock in kg

Livestock type	Field Survey 2016	Hamayun et al 2003	Teye & Sunkwa 2006	Kleeck 2006
Cattle	**543.30**	454.04	309	630
Goat	**45.31**	41.62	-	-
Sheep	**56.42**	-	-	55

Teye & Sunkwa, (2010) think their breed were unimproved

Table 11 tries to do a comparison between some works done on linear measurements for obtaining body weight for various livestock. It must be observed that these live weights were not done on the same group of animals but were done on a variety of different types of livestock in different years and within varying environments. The comparison is to only give a sense of relationship as to the veracity of Schaeffer's method of obtaining live weight livestock. Twumasi and Kosoe (2014), reveals 800 metric tons of municipal solid waste daily in 2014. This translates to 275,200 metric tons annually. This means solid slaughter waste makes 0.22% just from the three livestock, from the two slaughter houses using their figure as a base.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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